Defining Ethical Guidelines for Ambient Intelligence Applications on a Mobile Phone

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Abstract. Ambient Intelligence applications based on information and communication technology embedded in our environment and everyday objects raise several ethical issues. Even if ethical principles tend to be easily acceptable they are not so easy to concretize for design guidance. In this paper we describe how we have defined ethical guidelines for ambient intelligence applications on a mobile phone parallel to the development of the mobile phone platform architecture. Our aim has been to define guidelines that are concrete enough to be easy to understand and easy to follow by service and application designers as well as by platform developers. Our work highlights that it is possible and beneficial to study ethical issues when developing platforms and architectures for future applications. In that way we can identify ethical concerns well before the actual commercial application development takes place and we can find solutions to the concerns together with technology developers.

Keywords: Ambient intelligence, ethics, ethical guidelines, mobile services.

1 Introduction

Our ambient intelligence vision refers to an ambient intelligence environment, where the user has his/her personal mobile device as a medium of communication. The user can interact with everyday objects and surroundings and get information and services from and related to his/her local environment. To fulfil the vision, we have been participating in the development of a mobile architecture, including a personal mobile phone with access to wireless sensors and memory tags. The architecture facilitates many different applications that utilise embedded data or sensor measurements from the environment or the user him/herself.

In parallel with the technical development of the mobile architecture and the wireless sensors and tags, we have studied usage possibilities for the mobile architecture as well as user acceptance of those usages. The aim has been to recognise

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usage and application requirements and to analyse their implications for the technical development of both the mobile terminal and the components. A central part of the work has been ethical assessment of the usage possibilities. [1]

Ethical issues are frequently raised as ethical concerns of ambient intelligence [1,2,3]. Ethical issues are not just related to individual applications but they may require solutions on the infrastructure design as Wasieleski and Gal-Or [4] point out when discussing privacy issues related to RFID (Radio Frequency Identification) tags.

The aim has been to ensure that the mobile architecture to be developed will support, encourage and even force ethically sustainable applications. Ethical principles tend to be easily acceptable but not so easy to concretise and adapt to the design. Our aim is to define guidelines that would be concrete enough to be easy to understand and easy to follow by service designers and application developers. As we are working with the ethical guidelines parallel to the architecture design, we aim to have the guidelines ready before commercial application developments start.

In the following we will first describe the mobile architecture in more details and we will present some application scenarios. Then we will describe the process of defining the ethical guidelines. The process proceeded by first identifying ethical issues from a scenario set of future applications. The ethical issues could be classified according to six ethical principles. The ethical principles were further used as a framework to analyse key application features and to identify the implications of each ethical principle to these features.

2 Mobile Phone as a Platform for Ambient Intelligence Applications

Mobile phones have several advantages to be used as interaction tools in ambient intelligence environment: high penetration and acceptance amongst users, relatively low cost and small size, both local and long-range wireless connections, access to a wide range of services via the Internet, data storage possibility, and local computational capacity. The planned mobile architecture makes use of the mobile phone's capability of running software and providing several radio front-ends (Figure 1).

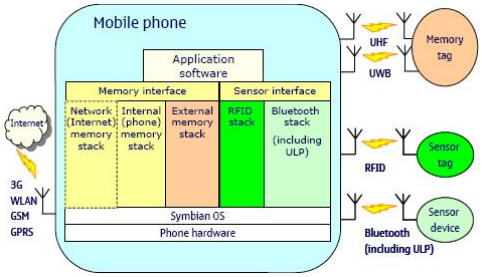


Fig. 1. Mobile phone platform for ambient intelligence applications

The user can communicate with the surrounding environment by wirelessly reading tags and sensors embedded to everyday objects and the environment itself.

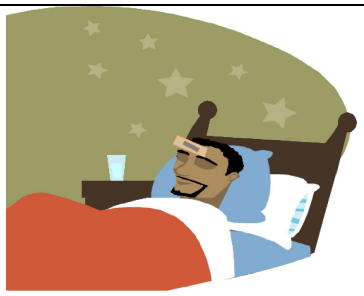
Alternatively sensor measurements can be collected and processed automatically by relevant applications on the mobile device. The mobile device can connect to the internet to exchange data with external servers. This feature is useful e.g. in storing and analyzing measurement data. The information, applications or services provided by the system are read or activated by touching or scanning tags and sensors with the mobile device, providing easy interaction methods to the user.

3 Usage Scenarios

Scenario-based design is an iterative approach to system design that relies on user interaction scenarios, or narratives, as the source of guidance for design requirements. These narratives describe how an archetypal person (with a set of goals, behaviours, and knowledge) would carry out a series of interactions with a system. [5, 6]

Usually scenario-based design is related to the development of an individual system or application [5, 6]. In our case we wanted to use scenarios to illustrate the wide variety of different applications that the mobile architecture would facilitate. Scenarios were central tools in the ethical assessment as will be described in the next section. The initial scenarios generated by the project group were evaluated with users and application field experts in focus groups and in web surveys. The scenarios were refined and new scenarios were written based on user feedback. In different phases of the project we created totally over 100 usage scenarios.

The scenario set includes six main scenarios that describe application demonstrators that will be developed parallel to the technical development of the mobile architecture. As example we illustrate one scenario in Figure 2 –smart plaster. The scenario description is slightly shortened from the original version.



Tom visits the health care centre at his work place because he has been awfully tired lately. The physician decides to study Tom's sleep quality. Tom gets a "Sleep quality logger" and the doctor advices him to put the plaster on his forehead and keep it there through the night. Tom follows the instructions and the plaster measures and logs EEG and acceleration data. In the morning Tom uses his mobile phone to read-out wirelessly the data captured by the plaster. The phone sends the data to the doctor to be further analysed.

Fig. 2. Examples of application scenarios

4 Ethical Assessment Process

The task of producing useful ethical guidelines is challenging, as the guidelines should provide a balance between conflicting values and interests. The guidelines should be based on ethical principles that highlight user needs, but are not too

individual-centric, taking into account e.g. societal or environmental interests. The guidelines should be practical enough for designers of ambient intelligence applications. Abstract instructions and ethical discussions will not help designers and engineers a lot in their everyday work. A balance between ethical principles and business benefits is also needed. The goal of the guidelines should be to give instructions to the designers to find ethically sound solutions to the practical design problems, while still promoting business economy [1].

A personal mobile terminal is a trusted device for personal data, providing facilities to ensure the user having control of different actions. This constitutes a good basis for ethically acceptable solutions. However, already during the first phases of developing the mobile architecture, several ethical issues related to the applications enabled by the mobile infrastructure were identified in user interviews [7]. The ethical issues recognised highlighted user requirements of awareness, control, and feedback of data stored in or mediated via the personal mobile device. There were concerns that personal data may be maliciously used to threaten the user's privacy or security. When things happen effortlessly, e.g. simply by touching or just being close to a tag, keeping the user informed gets extremely important [1].

Throughout the project, we have been supported in ethical issues by the Ethical Advisory Board of our project. The Advisory Board consists of 11 experts from different fields of ethics, e.g. ethics of e-health, social-ethical issues, legal issues and e-Inclusion. The work of the experts is voluntary and based on personal or professional interest in ethical issues related to novel technologies and ambient intelligence in society. The Ethical Advisory Board has assisted us in planning the process of generating the ethical guidelines and in the defining the guidelines. Ethical Advisory Board has given us versatile and valuable feedback on ethical issues.

The main tools to evaluate future applications facilitated by our mobile architecture were the scenarios presented in the previous section. The scenarios were evaluated with different experts and potential users to identify ethical issues related to future applications. The Ethical Advisory Board evaluated the scenarios and identified several issues to be improved in the scenarios and also general ethical concerns. The ethics experts classified their findings according to six ethical principles: privacy, autonomy, integrity and dignity, reliability, e-inclusion as well as the benefit for the society. This ethical framework was utilised later in our user evaluations.

We studied user acceptance of the suggested applications in five focus groups in Country1 and Country2. Three of the groups consisted of elderly people and two groups consisted of medical experts. The focus group participants watched the six main scenarios as animated films. After watching each video, the participants discussed about the scenario in a structured manner. The focus groups involved altogether 29 people. We also had web surveys in Country1, Country2 and Country3, involving altogether 250 respondents. The respondents were 18-60 years old and they represented both genders equally. In the web questionnaire each respondent assessed one of the six main application scenarios. The respondents saw the scenario as Flash animation. After watching the animation, the respondent assessed the scenario regarding ethical, usage and consumption topics. The third way to gather user feedback was proof of concept prototypes that facilitated studying and evaluating user interaction with selected application demonstrators in practice. We evaluated four different proof-of-concepts each with 4-8 users in laboratory conditions.

The main ethical concerns identified in the focus groups were the privacy of personal data and the sense of being surveyed, especially in health-related applications. Elderly users also thought that some of the proposed solutions were too technical and difficult, targeted only to younger people. Medical experts were concerned about the security of health data as it was transferred in the scenarios from the mobile phone to external servers. The medical experts also highlighted reliability of the system, accuracy of the measurements, technology replacing face-to-face examinations and unintentional misuse as ethical concerns.

In the web survey, the respondents were concerned about information confidentiality, system reliability and ease of use. With memory tags they were also concerned about knowing exactly what was being downloaded and worried about spam and protection for viruses. Possible compatibility problems with older phone models and ease of use for elderly and disabled people were also highlighted.

In the proof of concept evaluations the users emphasised control and predictability of the applications. For instance the user should see what information goes to his/her doctor. The test users also found some critical information lacking from the proof of concept demonstrators.

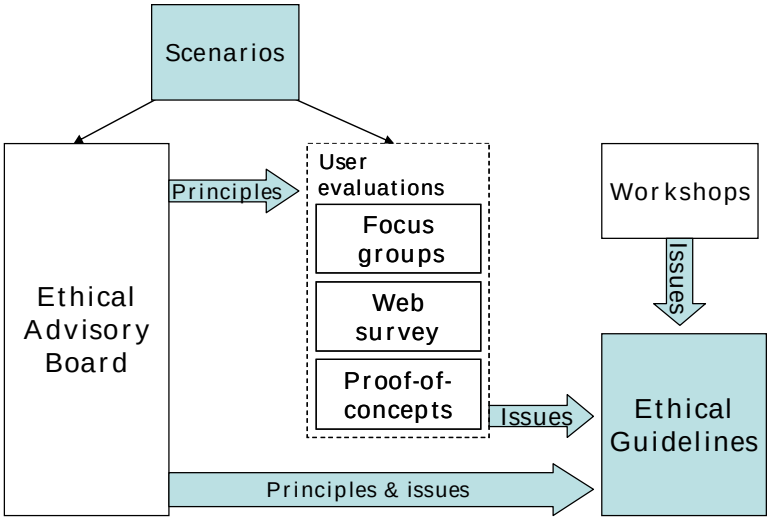


Fig. 3. Ethical guidelines are built on ethical principles and ethical issues identified by assessing application scenarios with different experts and potential users.

The first version of the Ethical Guidelines was written based the assessment of the scenarios by the Ethical Advisory Board and the identified issues were complemented with issues identified in user evaluations. The first version of the guidelines included ethical issues classified according to the ethical framework, i.e. the six ethical principles. For the second version of the guidelines we analysed the ethical issues further and connected them to key application features. In that way we could identify concrete implications of the ethical issues in ambient intelligence applications. The second version of the guidelines was finalised based in a workshop with the Advisory Board. The updates were mainly related to getting the guidance more concrete. For

the second version of the guidelines we wanted to get feedback from a wider audience. We organized a workshop in connection to an ethical computing conference to discuss about the guidelines with ethics and computing experts. We updated the guidelines with some new issues based on the group works and discussions in the workshop. In the following, we will present the Ethical Principles that were used as the framework for the guidelines. In this paper we cannot describe those guidelines in details and in practise so we just give an example how we analysed the ethical issues to implications to the core features of ambient intelligence applications, and finally generalized the implications as the Ethical Guidelines in their current form in Table 1.

Integrity and dignity	Is the application concept acceptable from user point of view as well as from the point of view of other people involved?

Table1. Example of Ethical guideline for application design

5 Ethical Principles for Ambient Intelligence Applications

Ethical principles are statements of human obligations or duties that are generally accepted and are the expression of normative ethical theories. Ethical principles should help us to decide among competing moral rules, mores, and values. The nature of these principles should be objective rather than subjective and the principles should be universal though not necessarily always absolute. Many apparent moral disagreements are really disagreements over the facts or over the definitions of crucial terms [8]. Best practises and most acceptable solutions can only be discovered by a thorough analysis [8]. Ethical principles constitute the framework for ethical guidelines. That is why the principles should be defined clearly and the definitions should be applied to the relevant application area.

Our ethical guidelines were built on the six ethical principles identified by the Ethical Advisory Group: privacy, autonomy, integrity and dignity, reliability, e-inclusion as well as benefit for the society. The ethical issues identified in the ethical assessment could be classified according to these principles as described in the previous section. In the following, we will shortly introduce the principles that became the framework for our ethical guidelines.

Privacy: an individual shall be able to control access to his/her personal information and to protect his/her own space.
The scenarios often introduced situations where personal data was collected and transferred to other people. For instance in the pill box scenario the information about the medication and the dosage is very private, and so is the sleep quality data in the smart plaster scenario.

Autonomy: an individual has the right to decide how and to what purposes (s)he is using technology.
Users should not be forced to use a technical solution. For instance in the pill box scenario, the patient should have the right to refuse using the smart pill box. Also the user should have the control of sending data to the doctor in both the pill box scenario

and in the smart plaster scenario. The user should also get clear feedback of data transfers.

Integrity and dignity: individuals shall be respected and technical solutions shall not violate their dignity as human beings.
Integrity refers to honesty and truthfulness. For instance in the memory tag scenario, the user should be able to trust that the tag offers what it promises and not for instance some embarrassing content. Dignity is the quality or state of being worthy of esteem or respect, and it may be violated if for instance the patient is dealt with as a measurement object and not as an individual.

Reliability: Technical solutions shall be sufficiently reliable for the purposes that they are being used for. Technology shall not threat user's physical or mental health.
The user should understand to what extent (s)he can rely on the technical solution. For instance the smart pill box only helps in monitoring the dosage but cannot be relied on as a reminder.

E-inclusion: Services should be accessible to all user groups despite of their physical or mental deficiencies.
E-inclusion is a common concern with all new technologies. In the scenarios elderly people were often presented as the people whose health parameters were measured. It should be ensured that the solutions are easy enough and affordable for elderly people.

Benefit to the society: The society shall make use of the technology so that it increases the quality of life and does not cause harm to anyone.
Role of the technology in the society is a very demanding issue and a single project cannot do much to ensure benefit to the society. However, even an individual project can raise ethical issues to public discussion.

6 Conclusions

Our aim has been to create concrete and clear ethical guidelines that could be used as check lists in designing a mobile phone platform for ambient intelligence applications and further in designing applications onto the platform. This aim has been quite ambitious as ethical principles tend to be easily acceptable but not so easy to concretise. We could give concrete check lists of some ethical issues but some issues are so application specific that we could only list issues that should be studied with users as part of the actual application development. Ethical issues need to be studied throughout the application design process both by user interviews and evaluations and by assessments carried out by experts of ethical issues.

The Ethical Guidelines is a living document that will be developing parallel to the application development. The guidelines are now publicly available, and we hope to

get feedback from people who start applying the guidelines in practise. Our work has given evidence that is possible and beneficial to study ethical issues when developing platforms and architectures for future applications. In that way we can identify ethical concerns well before the actual commercial application development takes place and we can try to find solutions to the concerns together with ethics experts and technology developers. The Ethical Advisory Board was a valuable resource that facilitated a versatile analysis of ethical issues. They also defined the ethical principles for ambient applications on a mobile phone. Those principles gave a solid framework for the ethical guidelines. Application scenarios turned out to be a useful tool for assessing future applications in cooperation with potential users, technology developers, application field experts and ethics experts. We have found that ethically sustainable solutions can be supported in platform design. Early focus on future applications also helps to raise ethical concerns of future technologies to be discussed in the society.

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